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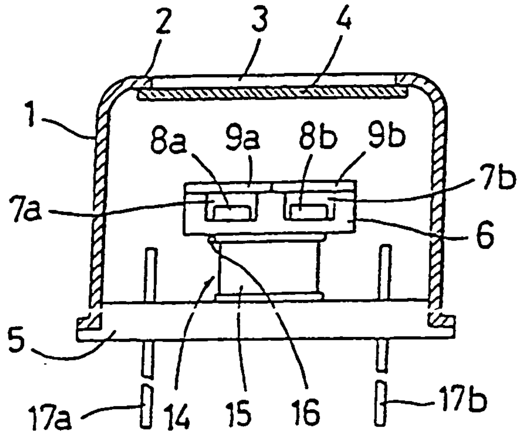
(54) Infrared ray detector.

(57) An infrared ray detector is disclosed in which four infrared ray detecting elements (8a-8d) are arranged corresponding to window materials (4) transmissible to infrared rays in a sealed case (1), of which openings (3) are closed with said window materials (4). Respective optical filters (9a-9d) transmissible to infrared rays having respective wavelength bands absorbed by a HC gas, a CO_2 gas, a CO gas and a standard gas are arranged between the respective window materials (4) and said respective infrared ray detecting elements (8a-8d). The central wavelength and a half-bandwidth of said wavelength bands of infrared rays transmissible through the respective optical filters (9a-9d) are set within a range of the following standard values ± about 5 %:

Optical filter for use in HC:
Central wavelength: 3.4 µm;
Half-bandwidth: 8.6 %
Optical filter for use in CO_2:
Central wavelength: 4.3 µm:
Half-bandwidth: 4.2 %
Optical filter for use in CO:
Central wavelength: 4.7 µm;
Half-bandwidth: 8.6 %
Optical filter for use in the standard gas:
Central wavelength: 3.8 µm;
Half-bandwidth: 3.0 %

Fig.1



INFRARED RAY DETECTOR

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an infrared ray detector used in for example an air-to-fuel radio meter and the like.

Description of the Prior Art

A selective infrared ray detector comprising a plurality of infrared ray detecting elements and a plurality of optical filters arranged corresponding to said respective infrared ray detecting elements has been disclosed in for example Japanese Patent Application Laid-Open No. Sho 50-17276.

The infrared ray detector disclosed in Japanese Patent Application Laid-Open No. Sho 50-17276 is provided with three chambers having a concave section formed in a body thereof independently, respectively. And, the infrared ray detecting element is arranged in the respective three chambers and the optical filters transmitting appointed wavelength bands of infrared rays corresponding to ingredients to be measured are inserted into mouth portions of the respective chambers to be mounted on said body of the infrared ray detector.

In this infrared ray detector, infrared rays, which have transmitted through the respective optical filters, are incident upon the respective infrared ray detecting element to put out outputs from the respective infrared ray detecting elements.

In addition, in said optical filters, spectral characteristics are shifted to longer wavelengths with a temperature-rise and the respective optical filters having different transmission wavelength bands are different in quantity of said shift.

An infrared ray detector adapted to regulate a temperature of optical filters in order to prevent influences effected upon the optical filters by said temperature-change has been disclosed in for example Japanese Utility Model Publication No. Sho 60-4110.

The infrared ray detector disclosed in Japanese Utility Model Publication No. Sho 60-4110, optical filters are arranged at respective end portions, which are separated from each other and stand side by side, of optical inlet ports provided in a V letter-shape in a metallic block while optical sensors mounted on a substrate are arranged at other end portions of said optical inlet ports, and said metallic block is provided with a temperature sensor and an endothermic-exothermic element mounted on a side portion thereof at a distance from said optical filter and optical sensor. And, a temperature of the metallic block is detected by means of the temperature sensor and the metallic block is cooled or heated by means of said endothermic-exthermic element on the basis of an output signal from the temperature sensor to regulate the temperature of the metallic block, whereby holding the optical sensor and the optical filter at a constant temperature.

Furthermore, an infrared ray detector provided with an infrared ray detecting element arranged in a cylindrical case has been disclosed in for example Japanese Utility Model Application Laid-Open No. Sho 64-48637.

In this infrared ray detector, a substrate is arranged in a cylindrical case formed of metals and the like, of which opened is closed with a window material transmissable to an appointed wavelength band of infrared rays, and said substrate is provided with an infrared ray detecting element mounted thereon. An, infrared rays, which have transmitted through said window material, are incident upon the infrared ray detecting element to put out an output.

Said infrared ray detector disclosed in Japanese Patent Application Laid-Open No. Sho 50-17276 detects three ingredients but a disadvantage has occurred in that the sensitivity is relatively low, in other words a quantity of measuring signal is small.

Next, the infrared ray detector disclosed in Japanese Utility Model Publication No. Sho 60-4110 is adapted to prevent a temperature-change of the optical sensor and optical filter. However, a temperature-change of the metallic block is detected and a temperature is regulated to hold the optical sensor and optical filter at the constant temperature. However, since there are differences in distance from the respective optical filters to the endothermic-exothermic element in view of the positional relation between the endothermic-exothermic element provided on the metallic block and two pieces of optical filters, it is difficult to regulate the temperature of both optical filters under the same condition and thus the temperature-change of the optical filter distant from the endothermic-exothermic element is increased. In addition, since the optical sensor is mounted on said metallic sensor through the substrate, a time-lag is produced in the regulation of the optical sensor in temperature.

Besides, in the infrared ray detector disclosed

in Japanese Utility Model Application Laid-Open No. Sho 64-48637, the infrared ray detecting element is arranged in the case provided with the window material in the opening portion but a side wall of the case is positioned around this infrared ray detecting element. Accordingly, of the infrared rays, which have transmitted through the window material to be incident upon the inside of the case, stray lights, which have been incident upon an inner surface and the like of the case and reflected from there, are directly incident upon the infrared ray detecting element, so that a problem has occurred in that an interference is apt to be produced.

Besides, in said infrared ray detector disclosed in Japanese Patent Application Laid-Open No. Sho 50-17276, the whole of the optical filter is inserted into the mouth portion of three chambers independently formed in the body of the infrared ray detector, respectively. Accordingly, a problem has occurred in that it costs much labor to install the respective optical filters.

In addition, if the respective optical filters are placed in the mouth portion of the respective chambers to be installed, the optical filters can be easily installed but a problem has occurred in that a light is leaked from the end face of the optical filter to produce the interference.

Furthermore, if for example the respective substrates composing the respective optical filters are different in material, the processing means and the like of the respective substrates are different depending upon the conditions, such as the hardnss of the respective material, so that the respective substrates have a difference in thickness in many cases. Accordingly, if a plurality of substrates 21, 21 having different thicknesses are put side by side on account of the difference in material, as shown in for example Fig. 7, steps 22 are produced at end faces of the substrates 21, 21, so that if infrared rays are incident upon the substrates 21, 21, a problem has occurred in that lights are leaked from steps 22 to interfer with each other.

SUMMARY OF THE INVENTION

The present invention solves the above described problems and it is an object of the present invention to provide a highly sensitive infrared ray detector, an infrared ray detector capable of uniformly carrying out the regulation of the optical filters in temperature, an infrared ray detector capable of preventing the influences by the stray lights, or an infrared ray detector having no possibility of the leakage of lights.

A first embodiment of an infrared ray detector according to the present invention relates to an infrared ray detector, in which four infrared ray detecting elements are arranged corresponding to window materials transmissable to infrared rays in a sealed case, of which openings are closed with said window materials, and respective optical filters transmissible to infrared rays having respective wavelength bands absorbed by a HC gas, a CO_2 gas, a CO gas and a standard gas are arranged between the respective window materials and said respective infrared ray detecting elements, characterized in that a central wavelength and a half-bandwidth of said wavelength bands of infrared rays transmissible through the respective optical filters are set within a range of the following standard values ± about 5 %:

Optical filter for use in HC:
Central wavelength: 3.4 µm;
Half-bandwidth: 8.6 %
Optical filter for use in CO_2:
Central wavelength: 4.3 µm;
Half-bandwidth: 4.2 %
Optical filter for use in CO:
Central wavelength: 4.7 µm;
Half-bandwidth: 8.6 %
Optical filter for use in the standard gas:
Central wavelength: 3.8 µm;
Half-bandwidth: 3.0 %.

A second embodiment is characterized in that substrates composing the respective optical filters have the same thickness and are adhered to each other at respective end faces with forming one surface and said integrated respective filters are fixedly mounted on a holder in which the respective infrared ray detecting elements are housed.

A third embodiment is characterized in that all the substrates according to said second embodimentare made of Si.

In addition, a quantum type-, a pyroelectric-, a pyro-, a thermopile infrared ray detecting element, such as PbSe, PbS and InSb, and the like can be optionally used as the infrared ray detecting element according to the first to third embodiments.

A fourth embodiment is characterized in that temperature-regulating means are arranged corresponding to the window materials transmissible to infrared rays in the sealed case, of which opening portions are closed with the window materials, and the holder made of highly heat-conductive materials, such as metals, mounted on a surface facing to the window material of said temperature-regulating means is provided with an optical filter transmissible to an appointed wavelength band of infrared rays, which have transmitted through the window material, and an infrared ray detecting element, upon which said infrared rays are incident, mounted on a side opposite to the temperature-regulating means to hold the temperature of the optical

filter constant by means of the temperature-regulating means.

A fifth embodimentis characterized in that a holder provided with a housing portion having a concave section is arranged in a sealed case, of which opening portions are closed with window materials transmissible to infrared rays, said housing portion of said holder being provided with an infrared ray detecting element corresponding to said window materials, and optical filters transmissible to appointed wavelength bands of infrared rays being mounted on the holder so as to close a mouth portion of the housing portion.

A sixth embodiment is characterized in that an inner surface of the case according to said fifth invention is roughened to make the absorption of infrared rays possible.

A seventh embodiment is characterized in that a plurality of infrared ray detecting elements are arranged in a sealed case, of which opening portions are closed with window materials transmissible to infrared rays, corresponding to said window materials, the same number of optical filters as said infrared ray detecting elements transmissible to appointed wavelength bands of infrared rays being arranged between the window materials and the respective infrared ray detecting elements, all of respective substrates of these optical filters being made of Si or Ge and having the same thickness, and said substrates being adhered to each other at respective end faces thereof to form one surface.

A quantum type-, a pyroelectric-, a pyro-, a thermopile infrared ray detecting element, such as PbSe, PbS and InSn, and the like can be optionally used as said infrared ray detecting element.

In addition, in the fourth to seventh embodiments,a number of the infrared ray detecting elements and optical filters is optionally selected.

With the infrared ray detector according to the first embodiments, since the central wavelength and the half-bandwidth of the wavelength band of the infrared rays transmissible through the respective optical filters is set as above described, respectively, a quantity of measuring signals is increased and thus the sensitivity is enhanced.

According to the second embodiment,since all of the substrates composing the respective optical filters have the same thickness and are adhered to each other at the end faces thereof to form one surface, the leakage of lights from said adhering faces can be prevented, and, since four optical filters are arranged so as to form one surface, the optical filters can be easily mounted on the holder.

According to the third embodiment, since all of the substrates are made of Si, which can be relatively easily cut, a quantity of chippings produced on a section being reduced, and a size of chippings produced being reduced, the leakage of lights from the end faces can be more easily prevented.

According to the fourth embodiment, since the holder of the infrared ray detecting element is provided with the temperature-regulating means on one side thereof and the optical filter on the other side thereof, the distances between the respective optical filters and the corresponding temperature-regulating means are almost same and the heat-conductance between the holder and the optical filter is smoothly made progress, whereby the regulation of all optical filters in temperature can be uniformly carried out.

In the infrared ray detector according to the fifth embodiment , since the infrared ray detecting element is arranged in the housing portion having a concave section of the holder arranged in the case, the stray lights can be prevented from being reflected by the holder to be incident upon the infrared ray detecting element even though the stray lights produced in the case are made progress toward the infrared ray detecting element and thus the interference resulting from the incidence of the stray lights upon the infrared ray detecting element can be prevented.

According to the sixth embodiment,since the inner surface of the case according to said fifth invention is roughened to make the absorption of the incident infrared rays possible, if the stray lights produced in the case are incident upon the inner surface of the case, the stray lights are absorbed to more surely prevent the incidence of the stray lights upon the infrared ray detecting element.

According to the seventh embodiment,since all of the substrates of a plurality of optical filters arranged in the case are made of any one of Si or Ge, that is all of the substrates are made of the same material, and all of the substrates are formed under the same conditions, the same thickness can be easily given to all of the substrates.

And, the optical filter is generally produced by alternatively vapor coating a substance having a high refractive index and a substance having a low refractive index many times on the surface of the respective substrates made of Si and the like formed in the suitable size depending upon the wavelength band of the infrared rays transmitting therethrough followed by cutting the substrate at appointed positions but Si can be relatively easily cut, the quantity of chippings produced in the cutting portion being reduced, and the size of chippings produced being remarkably reduced, so that if the optical filters are adhered to each other at the end faced thereof to form one surface, the leaking of lights from the chippings of the respective substrates can be more easily prevented

BRIEF DESCRIPTION OF THE DRAWINGS

The preferred embodiments of the present invention are shown in the drawings, in which

Fig. 1 is a sectional front view;

Fig. 2 is a partially cut off sectional plan view showing an optical filter;

Fig. 3 is an enlarged front view showing an optical filter;

Fig. 4 is an enlarged plan view showing an optical filter;

Fig. 5 is a diagram showing a relation between an absorption spectrum of a sample gas and an optical filter;

Fig. 6 is an enlarged front view showing an optical filter comprising one piece of substrate; and

Fig. 7 is an enlarged front view showing a substrate with steps at an end face.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments of the present invention will be below described with reference to the drawings.

Referring to the drawings, reference numeral 1 designates a cylindrical case made of metals and the like. An opening portion 3 formed on an end portion wall 2 of said case 1 being closed with a window material 4, such as sapphire, transmissible to infrared rays, and an inner surface of said case 1 being roughened by means of the sandblasting, the blackening treatment for roughening a surface and the like so as to absorb infrared rays. The case 1 is sealed up with a stem 5 and N_2 or dry air is enclosed in the case 1 to prevent a change with the lapse of time.

Reference numeral 6 designates a holder made of highly heat-conductive materials, such as aluminum, arranged in the case 1 corresponding to said window material 4, said holder 6 being provided with four groove-like housing portions 7a, 7b, 7c, 7d with one end closed and the other end opened, and said respective housing portions 7a, 7b, 7c, 7d being provided with PbSe 8a, 8b, 8c, 8d as an infrared ray detecting element housed therein.

Reference numerals 9a, 9b, 9c, 9d designate optical filters placed on a mouth portion of the housing portions 7a, 7b, 7c, 7d to be mounted on the holder 6 for selecting a wavelength band of infrared rays incident upon said respective PbSe 8a, 8b, 8c, 8d, said optical filter 9a being for HC, said optical filter 9b being for CO_2, said optical filter 9c being for CO, and said optical filter 9d being for the standard gas.

In the optical filters 9a, 9b, 9c, 9d, as shown in Figs. 3, 4, a band pass surface 11 (hereinafter referred to as BP surface) transmissible to an appointed wavelength band of infrared rays depending upon said respective ingredients to be measured is formed on one side of substrates 10 all made of Si and having the same thickness while a short-long cut surface 12 (hereinafter referred to as SLC surface) cutting a short wavelength band and a long wavelength band to remove noise ingredients other than said transmission bands is formed on the other side of said substrates 10. Said BP surface 11 and said SLC surface 12 is formed of a multi-layer film and the like made of germanium (Ge) and silicon monoxide (SiO), respectively.

And, a central wavelength and a half-bandwidth of the respective wavelength bands of infrared rays transmissible through the optical filters 9a, 9b, 9c, 9d are set as follows:

Optical filter 9a for HC:
Central wavelength: 3.4 µm;
Half-bandwidth: 8.6 %
Optical filter 9b for CO_2:
Central wavelength: 4.3 µm;
Half-bandwidth: 4.2 %
Optical filter 9c for CO:
Central wavelength: 4.7 µm;
Half-bandwidth: 8.6 %
Optical filter 9d for the standard gas:
Central wavelength: 3.8 µm;
Half-bandwidth: 3.0 %

The optical filters 9a, 9b, 9c, 9d having the above described construction are integrally adhered to each other with adhesives at end faces thereof so that the respective substrates 10 may form one surface and closely adhered to the holder 6 with adhesives corresponding to the respective PbSe 8a, 8b, 8c, 8d, as shown in Fig. 3.

Reference numeral 14 designates temperature-regulating means comprising a thermo-module 15 mounted on the stem 5 and a thermistor 16 overlapped on said thermo-module 15, said thermistors 16 being mounted on surfaces facing to the optical filters 9a, 9b, 9c, 9d of the holder 6. Reference numerals 17a, 17b designate lead pins passing through the stem 5. The connection of lead wires with said lead pins 17a, 17b is not shown.

In the infrared ray detector having the above described construction, the infrared rays, which are transmitted through the window materials 4, selectively transmit through the respective optical filters 9a, 9b, 9c, 9d to be incident upon the respective PbSe 8a, 8b, 8c, 8d, whereby simultaneously and separately detecting the respective infrared rays.

Although PbSe 8a, 8b, 8c, 8d are used as the

infrared ray detecting element in this infrared ray detector, the temperature of PbSe 8a, 8b, 8c, 8d is held almost constant through the holder 6 by means of the thermistor 16 and the thermo-module 15, so that the infrared rays can be detected in high selectivity.

At first, the first invention is described with reference to this infrared ray detector.

Fig. 5 shows relations between absorption spectrums of the respective gases and the optical filters 9a, 9b, 9c, 9d. In addition, also the respective optical filters for HC, CO_2, CO and the standard gas, which have been conventionally used, are described for comparison in this Fig. 5. Accordingly, the optical filters 9a, 9b, 9c, 9d in this preferred embodiment are shown by adding AF before the respective ingredients to be measured and the standard gas (shown by REF) and the conventional respective optical filters are shown by adding S before the respective ingredients to be measured and the standard gas (shown by REF).

As obvious from Fig. 5, both the central wavelength and the half-bandwidth of the wavelength band transmissible through the optical filter 9d for the standard gas are almost same as those of the conventional optical filter. However, the half-bandwidths of other optical filters 9b, 9c, 9d are set at values considerably larger than those of the conventional optical filter.

These respective central wavelengths and half-widths have been found in order to achieve an object of improving the sensitivity. The setting of the central wavelengths and the half-bandwidths of the optical filters 9a, 9b, 9c, 9d in the above described manner has led to an increase of the quanitity of measuring signal and thus to the possibility of detecting the respective infrared rays in high sensitivity.

And, a highly sensitive infrared ray detector exhibiting a high-speed response and a high selectivity with being hardly interferentially influenced can be obtained by using PbSe 8a, 8b, 8c, 8d as the infrared ray detecting element as in this preferred embodiment.

Since three ingredients, that is HC, CO_2 and CO, can be simultaneously detected in high selectivity and high sensitivity in such the manner, the infrared ray detector according to said preferred embodiment can be used as for example an air-to-fuel ratio meter exhibiting a high-speed response.

Although PbSe is used as the infrared ray detecting element in this preferred embodiment, this aims at the practical application of the high-speed response of PbSe, so that also the pyrosensor and the like can be used as the infrared ray detecting element.

Next, the second to seventh embodiments are described as for the infrared ray detector according to the invention.

As above described, in this infrared ray detector, all of the substrates 10 composing the respective optical filters 9a, 9b, 9c, 9d have the same thickness and are adhered to each other at the respective end faces thereof to form one piece of plate, as shown in Fig. 3, so that there is not the possibility that the infrared rays are leaked from the respective adhered end faces of the substrates 10 when said infrared rays are incident upon the optical filters 9a, 9b, 9c, 9d and thus the interference can be avoided. In addition, since four pieces of optical filter 9a, 9b, 9c, 9d are arranged on one surface, they can be easily mounted on the holder 6 without forming gaps and it is possible also to prevent the leakage of lights from the surface where the optical filters 9a, 9b, 9c, 9d are mounted on the holder 6.

If all of said substrates 10 are made of the same material, such as Si, the manufacturing conditions of the respective substrates 10 and the like are same, so that the thicknesses of all of the substrates 10 can be easily equalized. In addition, in the case of Si, the cutting is relatively easy, the quantity of chippings produced by this cutting being reduced, and the size of chippings produced being relatively small, so that it is possible to more surely prevent the leakage of lights from the adhered end faces of the respective substrates 10 adhered to each other.

Every material, such as Ge, transmissible to infrared rays can be used as a material forming the substrates 10.

Furthermore, the fourth embodiments as for this infrared ray detector is described.

In this infrared ray detector, PbSe, 8a, 8b, 8c, 8d is housed in the housing portion 7a, 7b, 7c, 7d of the holder made of a highly heat-conductive material, such as aluminum, respectively, the optical filters 9a, 9b, 9c, 9d being contactedly mounted on the holder 6, and temperature-regulating means 14 being mounted on a side opposite to the optical filters 9a, 9b, 9c, 9d of the holder 6.

Accordingly, in the case where the temperature of the holder 6 is detected by the thermistor 16 and the holder 6 is regulated at an appointed temperature by means of the thermo-module 15 depending upon the detected temperature, the holder 6 can be almost uniformly and effectively regulated in temperature all over it and also the temperature of all of PbSe 8a, 8b, 8c, 8d can be held constant. Moreover, since the optical filters 9a, 9b, 9c, 9d are contactedly mounted on the surface facing to the temperature-regulating means 14 of the holder 6, the heat-conductance between the holder 6 and the optical filters 9a, 9b, 9c, 9d can be smoothly carried out and the distances from all of the optical filters 9a, 9b, 9c, 9d to the cor-

responding temperature-regulating means 14 are almost equal, whereby it is possible that all of the optical filters 9a, 9b, 9c, 9d can be uniformly regulated in temperature to hold them at the constant temperature.

As above described, since all of the optical filters 9a, 9b, 9c, 9d can be uniformly held at the constant temperature, it is surely possible to prevent the shift of their spectral characteristics to longer wavelengths due to changes in temperature. In addition, since the optical filters 9a, 9b, 9c, 9d are uniformly transmissible to the appointed wavelength bands of infrared rays specified for them, infrared rays can be detected in high selectivity and high sensitivity and the interference value can be reduced.

Moreover, if all of the optical filters 9a, 9b, 9c, 9d are made of the same material, such as Si, and integrally adhered to each other at the end faces thereof, the expansion coefficient and the thermal conductivity of the respective substrates 10 are made uniform and thus the temperature characteristics are improved. Accordingly, the temperature-regulation of the optical filters 9a, 9b, 9c, 9d through the holder 6 can be more effectively and uniformly achieved and thus all of the optical filters 9a, 9b, 9c, 9d can be surely held at the constant temperature.

In addition, although an infrared ray detector provided with four PbSes 8a, 8b, 8c, 8d and four optical filters 9a, 9b, 9c, 9d was described in this preferred embodiments, the optical filters can be held at the constant temperature even though the number of the infrared ray detecting elements and the optical filters is smaller than 4.

Furthermore, in the infrared ray detector according to this preferred embodiment, PbSes 8a, 8b, 8c, 8d are housed in the groove-like housing portions 7a, 7b, 7c, 7d closed at one end provided in the holder 6 arranged in the case 1 (the fifth embodiment).

Accordingly, even though of the infrared rays, which have transmitted through the window material 4 to be incident upon the inside of the case 1, those, which have become stray lights, go in the respective directions toward the PbSes 8a, 8b, 8c, 8d, they are reflected by the side surfaces of the holder 6 and the like not to be incident upon the PbSes 8a, 8b, 8c, 8d, so that the influences by the interference resulting from the incidence of said stray lights upon the PbSes 8a, 8b, 8c, 8d and the like can be prevented.

Besides, the coloring of the holder 6 in black to absorb said stray lights incident upon the holder 6 by the holder 6 is more suitable to the elimination of the influences by the stray lights.

In addition, if the inner surface of the case 1 is roughened by the sandblasting, the blackening treatment for roughening the surface or the like so as to absorb infrared rays without reflecting them (the sixth embodiment), when the infrared rays, which have been incident upon the inside of the case 1 to become the stray lights, are incident upon the inner surface of the case 1 in the above described manner, the stray lights are absorbed without being reflect ed, so that the incidence of the stray lights upon the PbSes 8a, 8b, 8c, 8d can be more surely prevented and thus the interference resulting from the stray lights can be more surely prevented, whereby infrared rays can be detected in high accuracy.

As described in said description of the fifth embodiment, the coloring of the holder 6 in black to absorb the stray lights incident upon the holder 6 is more effective.

In addition, if a piece of substrate 10a made of for example Si is provided with a required number of BP surface 11 and SLC surface, respectively, as shown in Fig. 6, the problem of the steps brought about in the case, where a plurality of substrates 10 are adhered to each other, and the like can be easily solved. However, the number of the multilayer films composing the respective BP surfaces 11 and the respective SLC surfaces 12 is different on account of the difference in wavelength band of infrared rays to be transmitted. Accordingly, although the formation of the BP surfaces 11 and the SLC surfaces 12 has a technical difficulty and the like, also the optical filter shown in Fig. 6 is effective if these problems can be solved.

Of the infrared ray detectors according to the present invention, the infrared ray detector claimed in Claim (1) is a selective infrared ray detector comprising the optical filter for use in HC, the optical filter for use in CO_2, the optical filter for use in CO and the optical filter for use in the standard gas but the central wavelengths and the half-band-widths of the wavelength bands of infrared rays transmissible through said respective optical filters are set in the above described manners, respectively, so that the quantities of measuring signals corresponding to the respective ingredients to be measured are increased and thus the respective ingredients to be measured can be measured in high sensitivity, whereby the accuracy of measurement can be improved.

In the infrared ray detector claimed in Claim (2), all of the respective substrates composing the respective four pieces of optical filter in the infrared ray detector claimed in Claim (1) have the same thickness and adhered to each other at the respective end faces thereof to form one surface, whereby four optical filters are integrated. Accordingly, in the event that infrared rays are incident upon these optical filters, the leakage of lights from the adhered end faces of the respective optical filters can

be prevented. In addition, the integrated four pieces of optical filter are mounted on the holder provided with the infrared ray detecting elements mounted thereon but the respective optical filters are all arranged on one surface, so that the optical filters can be mounted on the holder without forming gaps and thus the leakage of lights from the surface, where the respective optical filters are mounted on the holder, can be prevented, whereby the interference resulting from the leakage of lights and the like can be more surely prevented.

And, in the infrared ray detector claimed in Claim (3), all of the respective substrates of four optical filters in the infrared ray detector claimed in Claim (2) are made of Si, so that the thicknesses of the respective substrates can be easily equalized to each other and thus the expansion coefficient and the thermal conductivity can be made uniform, whereby the regulation of the respective optical filters in temperature can be effectively and uniformly achieved. And, since Si can be easily cut, the quantity of chippings produced by the cutting being reduced, and the size of chippings produced being relatively small, it is possible to more surely prevent the leakage of lights from the adhered end faces of the substrates adhered to each other.

In the infrared ray detector claimed in Claim (4), the holder made of a highly heat conductive material is mounted on the temperature-regulating means and the optical filter is mounted on the surface facing to the temperature-regulating means of the holder. Accordingly, the distances from all of the optical filters mounted on the holder to the temperature-regulating means are almost equalized, so that all of the optical filters can be uniformly regulating in temperature and thus held at the constant temperature. Accordingly, the influences resulting from the temperature-change, such as the shift of the spectral characteristics of the optical filter to longer wavelengths resulting from the temperature-change, can be eliminated and thus infrared rays can be detected in high sensitivity. And, the selective infrared ray detector can reduce the interference value to improve the selectivity.

In the infrared ray detector claimed in Claim (5), the infrared ray detecting element is housed in the housing portion having the concave section of the holder arranged in the case. Accordingly, even though the infrared rays, which have transmitted through the window material of the case to become the stray lights, go in the direction toward the infrared ray detecting element, they are reflected by the holder not to be incident upon the infrared ray detecting element, so that the influences, such as the interference, resulting from the incidence of the stray lights upon the infrared ray detecting element can be prevented.

In addition, in the infrared ray detector claimed in Claim (6), the inner surface of the case is roughened by the sandblasting, the blackening treatment for roughening the surface and the like in the infrared ray detector claimed in Claim (5), so that when the infrared rays, which have become the stray lights within the case, are incident upon the inner surface of the case, they are absorbed without being reflected to be reduced, whereby the incidence of the stray lights upon the infrared ray detecting element can be more surely prevented and thus infrared rays can be detected in high accuracy.

In the infrared ray detector claimed in Claim (7), all of the respective substrates of the optical filters provided for a plurality of infrared ray detecting elements, respectively, arranged within the case are made of any one of Si and Ge, having the same thickness, and being adhered to each other at the respective end faces to form one surface.

Accordingly, there is not the possibility that infrared rays are leaked from the respective adhered end faces of the substrates and thus the interference can be prevented from being produced when the infrared rays are incident upon the respective optical filters. In addition, since there is no possibility of the leakage of lights from the end faces of the substrates in such the manner, a plurality of optical filters arranged on one piece of plate can be optionally mounted on the holder of the infrared ray detecting elements and thus the optical filters can be easily mounted on the holder.

And, since all of the substrates of a plurality of optical filters are made of any one of Si and Ge, the thicknesses of the respective substrates can be easily equalized to each other, the expansion coefficient and the thermal conductivity being made uniform, and the temperature characteristics being improved, whereby the regulation of the respective infrared ray detecting elements in temperature can be efficiently achieved in case of need. In addition, in the case where the respective substrates are made of the same material and adhered to each other with adhesives, the adhering coditions are same, so that the adhesion can be easily carried out and strengthened.

If the substrates are made of Si, Si can be easily cut, the quantity of chippings produced by the cutting being reduced, and the size of chippings produced being relatively small, so that the leakage of lights from the adhered end faces of the substrates adhered to each other can be more surely prevented.

The "half-bandwidth" in the present invention is concretely described as follows giving the case of the CO_2 filter as an example.

As found from Fig. 5 the Peak transmittance of the CO_2 filter is about 86%. 1/2 times the Peak

transmittance is 43% and the width at that position is about 0.18 µm.

As below described, about 4.2% is obtained by dividing this 0.18 µm by 4.3 µm as the central wavelength and then multiplying the resulting quotient by 100.

$0.18 \div 4.3 \times 100 = 4.2$

This 4.2% is the half-bandwidth.

Claims

1. An infrared ray detector, in which four infrared ray detecting elements (8a-8d) are arranged corresponding to window materials (4) transmissible to infrared rays in a sealed case (1), of which openings (3) are closed with said window materials (4), and respective optical filters (9a-9d) transmissible to infrared rays having respective wavelength bands absorbed by a HC gas, a CO_2 gas, a CO gas and a standard gas are arranged between the respective window materials (4) and said respective infrared ray detecting elements (8a-8d), **characterized in that** a central wavelength and a half-bandwidth of said wavelength bands of infrared rays transmissible through the respective optical filters (9a-9d) are set within a range of the following standard values ± about 5 %:
Optical filter for use in HC:
Central wavelength: 3.4 µm;
Half-bandwidth: 8.6 %
Optical filter for use in CO_2:
Central wavelength: 4.3 µm:
Half-bandwidth: 4.2 %
Optical filter for use in CO:
Central wavelength: 4.7 µm;
Half-bandwidth: 8.6 %
Optical filter for use in the standard gas:
Central wavelength: 3.8 µm;
Half-bandwidth: 3.0 %

2. The infrared ray detector as claimed in claim 1, **characterized in that** all of substrates (10) composing said respective optical filters (9a-9d) have the same thickness and are adhered to each other at respective end faces with forming one surface and said integrated respective optical filters are fixedly mounted on a holder (6) in which the respective infrared ray detecting elements (8a-8d) are housed.

3. The infrared ray detector as claimed in claim 2, **characterized in that** all of said substrates (10) composing the respective optical filters (9a-9d) are made of Si.

4. An infrared ray detector, **characterized in that** temperature-regulating means (14) are arranged corresponding to window materials (4) transmissible to infrared rays in a sealed case (1), of which the opening portions (3) are closed with said window materials (4), and a holder (6) made of highly heat-conductive mate rials, such as metals, mounted on a surface facing to the window material (4) of said temperature-regulating means (14) is provided with an optical filter (9a-9d) transmissible to an appointed wavelength band of infrared rays, which have transmitted through the window material (4), and an infrared ray detecting element (8a-8d), upon which said infrared rays are incident, mounted on a side opposite to the temperature-regulating means (14) to hold the temperature of the optical filter (9a-9d) constant by means of the temperature-regulating means (14).

5. An infrared ray detector, **characterized in that** a holder (6) provided with a housing portion (7a-7d) having a concave section is arranged in a sealed case (1), of which opening portions (3) are closed with window materials (4) transmissible to infrared rays, said housing portion (7a-7d) of said holder (6) being provided with an infrared ray detecting element (8a-8d) corresponding to said window materials (4), and optical filters (9a-9d) transmissible to appointed wavelength bands of infrared rays being mounted on the holder (6) so as to close a mouth portion of the housing portion (7a-7d).

6. An infrared ray detector as claimed in claim 5, **characterized in that** an inner surface of said case (1) is roughened to make the absorption of infrared rays possible.

7. An infrared ray detector, **characterized in that** a plurality of infrared ray detecting elements (8a-8d) are arranged in a sealed case (1), of which opening portions (3) are closed with window materials (4) transmissible to infrared rays, corresponding to said window materials (4), the same number of optical filters (9a-9d) as said infrared ray detecting elements (8a-8d) transmissible to appointed wavelength bands of infrared rays being arranged between the window materials (4) and the respective infrared ray detecting elements (8a-8d), all of respective substrates (10) of these optical filters (9a-9d) being made of Si or Ge and having the same thickness, and said substrates (10) being adhered to each other at respective end faces thereof to form one surface.

Fig.1

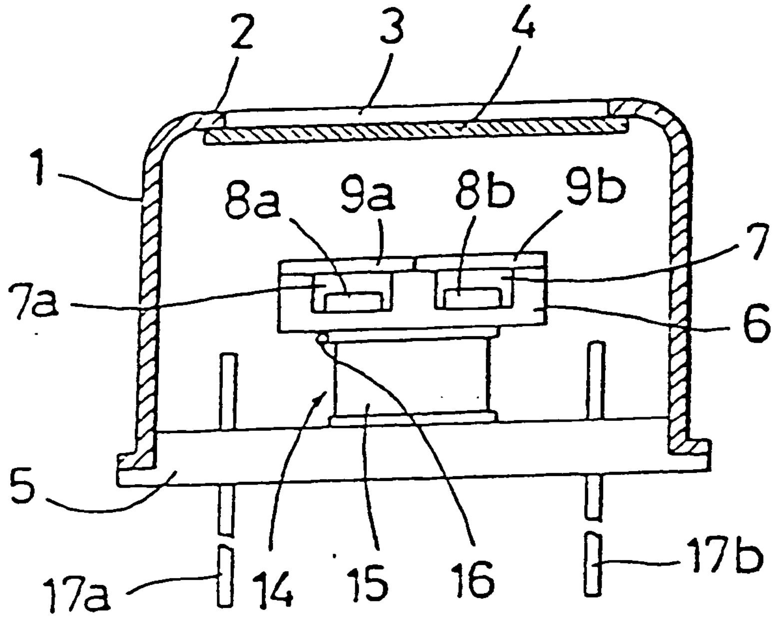

2
3
4
1
8a
9a
8b
9b
7b
7a
6
5
14
15
16
17a
17b

Fig.2

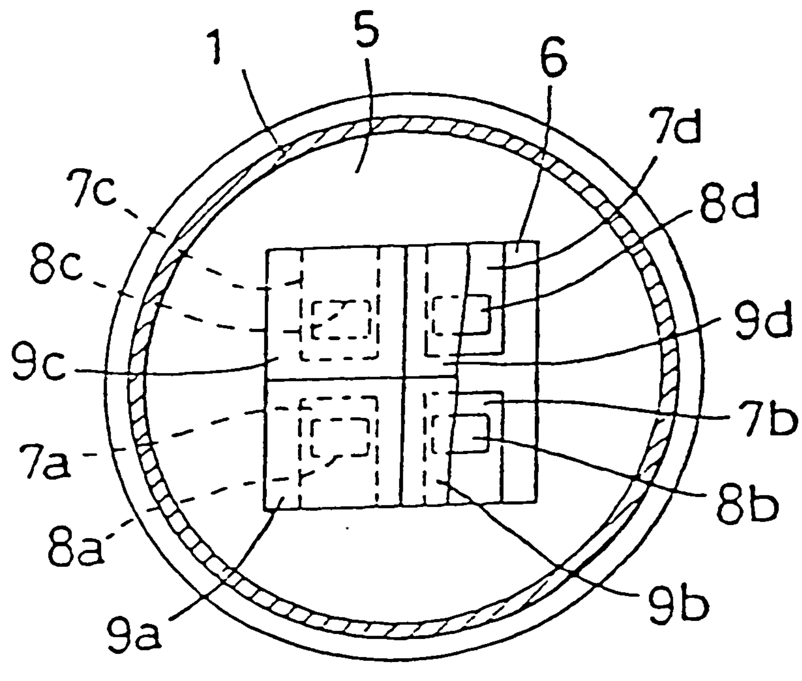

1
5
6
7d
7c
8d
8c
9d
9c
7b
7a
8b
8a
9b
9a

Fig.3

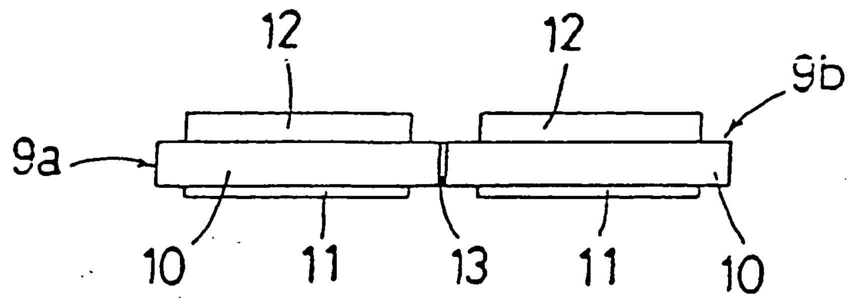


Fig.4

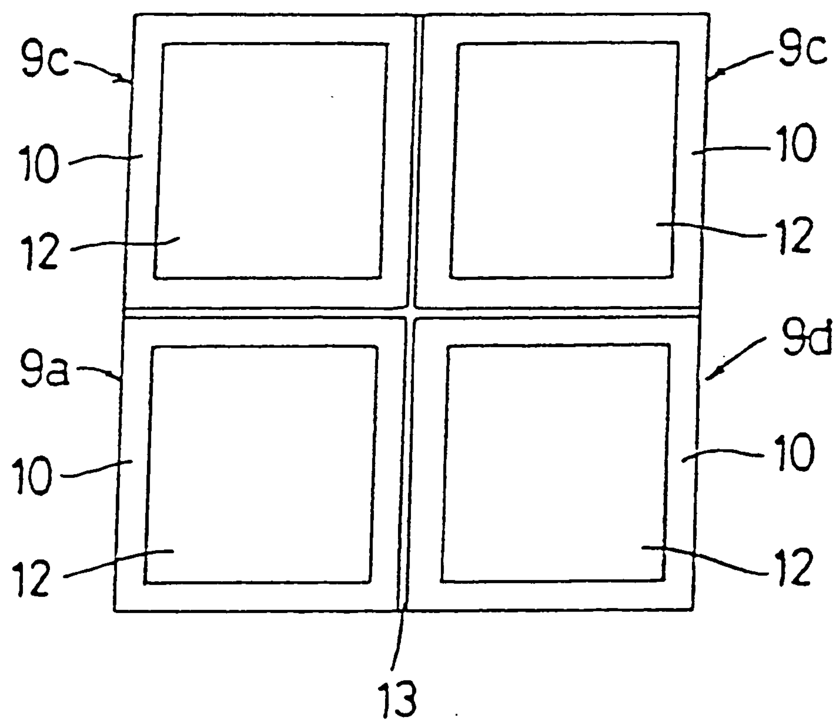
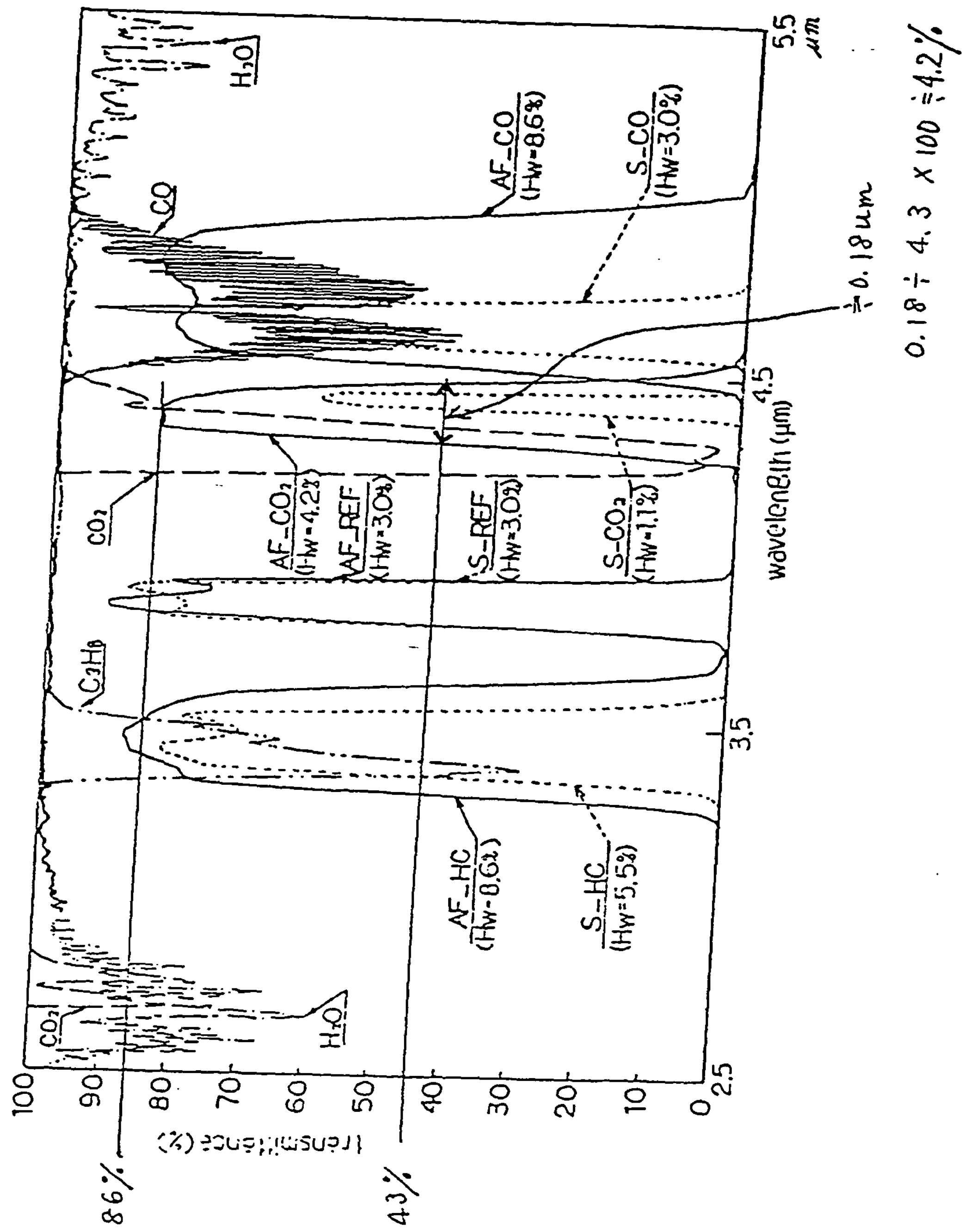


Fig.5



Transmittance (%)
wavelength (μm)
86%
43%
CO_2
H_2O
C_3H_8
CO
AF_HC (Hw=8.6%)
S_HC (Hw=5.5%)
AF_CO_2 (Hw=4.2%)
AF_REF (Hw=3.0%)
S_REF (Hw=3.0%)
S_CO_2 (Hw=1.1%)
AF_CO (Hw=8.6%)
S_CO (Hw=3.0%)
≒0.18um
0.18 ÷ 4.3 × 100 ≒ 4.2%

Fig.6

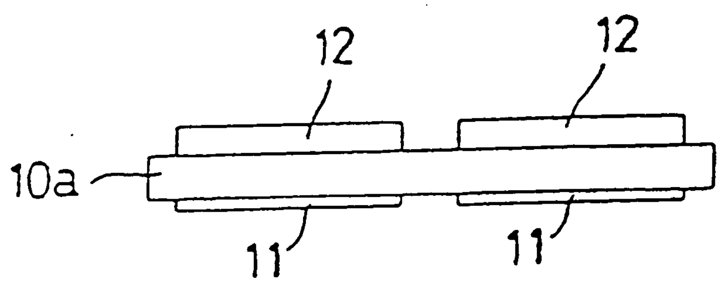
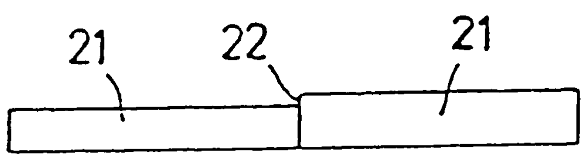


Fig.7



European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90118708.8

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	EP - A2 - 0 226 569 (AVL) * Column 2, line 9 - column 5, line 51; fig. 1-3 * --	1	G 01 J 3/36 G 01 N 21/35 G 01 N 21/61
X	EP - A2 - 0 123 458 (EDINBURGH INSTRUMENTS) * Page 13, line 17 - page 14, line 12; fig. 2 *	5-7	
A	--	1-3	
A	US - A - 4 829 183 (MC CLATCHIE et al.) * Column 5, lines 30-62; fig. 1 * --	1-4	
A	DE - A1 - 3 608 122 (PIERBURG) * Column 5, lines 9-29; fig. * --	1	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
D,A	US - A - 3 860 344 (GARFUNKEL) & JP-A2-50-177 276 * Column 4, line 45 - column 5, line 48; fig. 1 * ----	1	G 01 J 3/00 G 01 N 21/00 H 01 L 27/00 H 01 L 31/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	17-12-1990	BAUER

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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& : member of the same patent family, corresponding document